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FLOW MEDIUM-DRIVEN HAND-HELD POWER TOOL

The invention is based on a flow-medium-driven hand-held power tool as generically defined by the preamble to claim 1.

From US Patent 6,347,985 B1, a hand-held power tool is known that is driven solely by way of the suction air flow of a vacuum cleaner. The key element in the known hand-held power tool is a conventional Pelton turbine, which uses the suction air of the vacuum cleaner for rotating the power takeoff spindle and thus for driving the tool.

The efficiency of the known hand-held power tools, with axial and Pelton turbines, also known as resistance rotors, which output a mechanical power to a shaft solely on the basis of the air pulse, are only limitedly capable of meeting stringent requirements in terms of the working performance and suction extraction power of these hand-held power tools that are capable of being operated with commercially available vacuum cleaners.

Advantages of the Invention

The invention having the characteristics of claim 1 has the advantage that the hand-held power tool, designed without its own electric motor and operated as a sander with only the suction air of a vacuum cleaner, has such high efficiency for its intended purposes that an especially large amount of flow energy from the suction air or blown air can be converted into mechanical power, and virtually dust-free sanding, drilling or the like, with continuous removal of the dust particles produced in the sanding process, is assured, thus combining a high degree of chip removal with highly effective suction extraction of the sanding dust; in short, an especially advantageous variety of turbine - a kind of hybrid between a classical radial turbine with a flow through it and an axial turbine - is created, which is designed as a radial turbine that has a diagonal flow through it. It combines the advantage of low pressure loss with that of increased energy yield from the air flow and therefore forms a highly effective drive mechanism for electric tools that have

an air flow through them.

Because there is a fixed upstream baffle, located in front of the turbine wheel and acting as a bearing seat for a rotary bearing of the axial shaft of the turbine wheel, it takes on a load-bearing function of the housing structure of the hand-held power tool, and thus the production costs for the hand-held power tool can be kept especially low.

Because the drive mechanism comprises only lightweight plastic parts, the hand-held power tool is especially light in weight and handy.

Because the turbine wheel is sealed off from the turbine housing by a labyrinth seal, the turbine is sealed off without friction losses and thus protected against a pressure loss, so that its efficiency is especially high.

Because the upstream baffle serves as a bearing seat for a bearing of the axial shaft of the turbine, the hand-held power tool equipped with it can be made especially low in height.

Because it has a compensation mass which jointly with structures of the upstream baffle forms a labyrinth seal, the bearing of the axial shaft is especially securely protected against the penetration and deposition of dust.

Because the upstream baffle is built into the structure of the housing in such a way that it reinforces the housing, it can be constructed in an especially lightweight fashion.

Because the air for driving the turbine wheel is brought to it radially outward and then is vacuumed obliquely inward from the outer edge of the turbine wheel, flow losses are especially low, and the turbine has especially high efficiency.

Because the hand-held power tool is provided with a radio switch, with which the vacuum cleaner can be switched on and off, convenient, simple operation of the hand-held power tool and of the vacuum cleaner is possible.

Because the speed governing for the hand-held power tool is done by means of a variably adjustable air flap, adapting the rpm of the power tool to the working conditions at the time can be done easily and inexpensively.

Drawing

The present invention is described in further detail below in terms of an exemplary embodiment and the associated drawing.

Shown are:

Fig. 1, a longitudinal section through an orbital sander;

Fig. 2, a longitudinal section through the turbine with the upstream baffle for driving the orbital sander;

Fig. 3, a side view of the turbine with the compensation mass;

Fig. 4, an enlarged detail of Fig. 3;

Fig. 5, a three-dimensional top view on the compensation mass;

Fig. 6, a three-dimensional bottom view of the upstream baffle.

Description of the Exemplary Embodiment

Fig. 1 shows a hand-held power tool 10, designed as an orbital sander, looking toward a housing shell 14 whose inside faces toward the observer. This shell, together with a second, substantially symmetrical housing shell, not shown, forms a bell-shaped housing 12 with a vertical axis 40. The housing is put together from the two housing shells using screws, which pass from the outside through the outer housing shell, not shown, and are rotatable in screw domes 35 in the left housing shell 14 and as a result hold the two housing shells together at a butt joint.

On its top 20, the housing 12 changes over into a hollow-cylindrical handle 16, protruding transversely from the vertical axis 40, that serves as a suction air outlet 18 and as a means of attaching a suction hose, not shown. On its top 20, the housing 12 has an air flap 22, which as needed opens or closes an opening 24 to the flow conduit 26 in the interior of the housing 12 for the sake of regulating the entry of air. To that end, a region 86 of a conduit wall 28 close to the opening 24 is perforated, so that the suction air can communicate with the outside air in the hoselike flow conduit 26. The conduit wall 28 is retained on the housing shells 14 by load-bearing ribs 30. The load-bearing ribs 30 are joined to reinforcing ribs 32 in the interior of the housing shell 14 and via these ribs are joined to the outer housing wall or housing shell 14. As a result, the air conduit 26 or conduit wall 28 is reinforced, and the housing 12 of lightweight construction is stabilized in particular against vibration or resonance induced by suction air as it flows through.

At the bottom, the housing 12 ends in a straight, encompassing lower edge 34, which in its vertical projection downward forms a triangle with convex sides. Located parallel to the lower edge 34 is a sanding disk 70, which is elastically movably joined to the housing 12 via elastic oscillating bodies 75. The sanding disk 70, with its outline of an iron for clothing, protrudes on the outside past the triangular contour of the lower edge 34 projected vertically downward, and on its underside it has retention means for receiving a sanding sheet, not shown. It can be driven orbitally via an axial shaft 72 and an eccentric, not identified by reference numeral, seated on its end in a manner fixed against relative rotation, so that every point of the sanding disk and thus each individual grain on the sanding sheet describes small circles, which is the typical sanding pattern of an orbital sander.

The axial shaft 72 is slaved in rotating fashion via a turbine wheel 38 of an air-drivable turbine 36 and is rotatably supported in the housing 12 and in the upstream baffle 74 via one upper and one lower roller bearing 64, 66, and with its lower end it engages a third roller bearing 68, which is seated with its outer ring in a manner fixed against relative rotation in the sanding disk 70. Between the lower roller bearing 66 and the third roller bearing 68, the axial shaft 72 is joined in a

manner fixed against relative rotation to a compensation mass 78, which serves as an imbalance compensator, to keep vibration of the eccentrically moved sanding disk 70 away from the housing 12.

The compensation mass 78, on its upper side toward the upstream baffle 74, has an upward-protruding annular profile 80. This profile is embraced at the top by an annular groove 82 with a slight spacing, this groove being located in the closely adjacent underside of the upstream baffle 74 and together with the annular profile 80 jointly forming a lower, meandering labyrinth seal 84. This seal prevents dust and chips from being moved in the gap or to the lower bearing 66 as a result of the underpressure in the hollow chambers in the interior of the hand-held power tool 10, and in particular between the compensation mass 78 and the upstream baffle 74, so that the lower bearing remains unimpaired for a long time.

The axial shaft 72 is embraced centrally by the turbine wheel 38 in a manner fixed against relative rotation, and an intimate form-locking connection is made between the two parts, by means of knurling 73 in a defined circumferential region, approximately in the middle of the axial shaft 72, into the indentations of which the plastic, which is liquid in the casting process, enters and thus brings about the connection.

The turbine wheel 38 has a bell-shaped outer contour, and the lower edge 34 is adjoined axially downward by an upstream baffle 74 with baffle blades 75 that is held in the housing 12 in a manner fixed against relative rotation or can be clamped between the housing shells 14. The baffle blades 75, like the wheel blades 42 of the turbine wheel 38, are designed as plastic strips standing on their short sides. The upstream baffle 74, designed as a short truncated cone, is embraced on the outside at least partially by the turbine housing 60, likewise placed in the housing 12 in a manner fixed against relative rotation, at the spacing of the height of the baffle blades 75, so that a lower extension of the annular flow conduit 49 of the turbine wheel 38 is thus formed, through which the suction air is drawn or conducted. Via the baffle blades 75, the suction air flowing in from below is steered, for driving the turbine wheel 38, in the flow direction of the turbine wheel, or in the flow direction of the flow conduit 49 or of the wheel blades 42 of

the turbine wheel 38, and is calmed, so that as a result the efficiency of the turbine 36, especially on the inlet side, is improved considerably. The upstream baffle 74, with a central recess 76 on its underside, forms a bearing seat for a bearing 66 of the lower region of the axial shaft 72, which bearing fixes the axial shaft in the housing 12 and guides it.

Fig. 2 shows a detail in longitudinal section through the turbine wheel 38, with the upstream baffle 74 adjoining it axially at the bottom and fixed in the housing 12, which is shown assembled in Fig. 1. Here, a frustoconical convex load-bearing cone 48, shaped somewhat like the body of a lemon squeezer, can be seen which has a plurality of wheel blades 42 on its outside that are in the form of flat plastic strips standing with their short side on the load-bearing cone 48, and whose height increases gradually in the direction toward the - virtual - tip of the cone. Via the wheel blades 42, a conical cap 44, extending approximately parallel to the load-bearing cone 48 or to the upper edges of the wheel blades 42, is guided. As a result, the flow conduit 49 of annular cross section is formed between the load-bearing cone 48 and the conical cap 44. This flow conduit is divided up by the wheel blades 42 into a plurality of winding individual conduits, in which the suction air for driving the turbine 36 can flow with especially low flow resistance, because of the short bending radii or small deflection angles of the wheel blades 42. The lower edge of the load-bearing cone 48 is inclined relative to the vertical axis 40 by approximately 45θ and does not, as in conventional radial turbines, extend at an angle of approximately 90θ transversely to the cone axis. In an especially favorable exemplary embodiment of the turbine 36, the inflow angle of the blade is 40θ, and the outflow angle is 30θ. An arrow 62 indicating motion shows that the air flowing along the wheel blade 42 is deflected by 45θ, measured relative to the axis 40; the deflection transversely to the plane of the drawing is not yet taken into account.

At the top, in the region of the virtual tip 46 of the cone, the conical cap 44, with minimal spacing, borders on the conduit wall 28 of the air conduit 26, through which the suction air is guided in a streamlined way to the underpressure source or to the vacuum cleaner.

The load-bearing cone 48 or truncated cone of the turbine wheel 38 is penetrated by a central hollow cylinder 54 for receiving the axial bolt 72. Toward the top, in the region of a virtual tip of the cone, the hollow cylinder forms a relatively tall annular collar 52 that protrudes far above the tip. As a result, the hollow cylinder 54 attains a length such that the axial shaft 72, given a defined axial oversize and given a defined region of its knurling 73, is positioned relative to the turbine wheel in a way that is secured with this knurling 73 in the interior of the hollow cylinder 54 and is embraced by that cylinder, so that a secure rotary fixation is achieved between the turbine wheel 38 and the axial shaft 72.

The frustoconical conical cap 44, with increasingly concave curvature in the direction of the virtual tip 46, has an annular sealing bead 56 on its outside, a third of the way up. This bead is intended for axial engagement with an annular groove 57, located toward the turbine wheel 38 inside the shell-like turbine housing 60, that fits over the sealing bead 56 and thereby functions as an upper labyrinth seal 51 and prevents pressure losses in the interior of the turbine 36 and thus enhances the turbine efficiency considerably.

For operating the hand-held power tool 10, air is extracted by suction at the suction air outlet 18 and flows through suction extraction openings 71 in the sanding disk 70 and in from the outside between the top of the sanding disk 70 and the lower edge 34 of the housing. The air aspirated from outside gets into the annular conduit 49 of the upstream baffle 74 and onward into that of the turbine wheel 38.

The contact of the turbine wheel 38 and of the upstream baffle 74 with abrasive air containing dust can lead there to a grinding down and dust deposition effect, which can impair the performance of the drive mechanism and its service life. To counteract this, the surfaces touched by suction air are structured, in particular by means of small, typically golf- ball-like dimples, such that they have low flow resistance with increased surface strength.

Fig. 3 shows a longitudinal section through the turbine 36 with the upstream baffle 74, the installed axial shaft 72, and the lower bearing 66, compensation

mass 78, and disk bearing 68. The lower labyrinth seal 84 can be seen clearly, as can the elements of this seal shown enlarged in Fig. 4, namely the annular profile 80 on top of the compensation mass 78 and the annular groove 82 in the underside of the upstream baffle 74 by individual dimples made in the reinforcing ribs 96 for stabilizing the load-bearing ring 77.

Fig. 5 shows a three-dimensional top view on the compensation mass 78, and the annular profile 80 that forms the labyrinth seal 84 is clearly visible.

Fig. 6 shows a three-dimensional bottom view of the upstream baffle 74; the annular groove 82 is visible in the underside, or in the form of individual dimples in the reinforcing ribs 96.

The air that flows through the hand-held power tool 10 does not, as in a classical radial turbine, flow purely radially inward before it is deflected axially again in the turbine 36, but instead, both in the upstream baffle 74 and in the turbine 36, it flows at an angle of approximately 40θ to the vertical axis 40 (see Figs. 3 and 4). This oblique oncoming flow has the advantage that the efficiency of the turbine 36 is increased markedly, since the pressure loss inside the turbine 36 and inside the upstream baffle 74 is minimized. The inflow angle of the blade is 60θ, and the outflow angle is 30θ, to keep the outflow losses as slight as possible. The angles for the inflow region can vary between 0θ and 70θ, and the angles in the outlet region can vary between 10 and 60θ. The choice of the angles depends both on the air quantity and on the expected rpm. The upstream baffle 70 has the task of imposing the greatest possible pilot spin on the air flow, and for this reason it has baffle blades 75 with an outlet angle of 78θ (Fig. 8). To minimize the air noises, the wheel blades 42 of the turbine wheel 38 are drawn somewhat forward at the load-bearing cone 48 and in contrast to this the baffle blades 75 are drawn somewhat rearward (Figs. 4 and 6). Whistling noises between the wheel blades 42 and baffle blades 75 are thus suppressed, since these blades sweep past one another with a spacing of only 0.5 mm and become effectively "lubricated". The slight spacing between the upstream baffle 74 and the turbine 36 is necessary so that the turbine 36 will have an ideal oncoming flow. An additional bracing ring 88 between the bracing ribs 90 on the inside and on the underside of the load-bearing

cone 48 prevents a sharply fluctuating and uncontrolled idling rpm of the turbine 36, which can assume very high values (> 20,000 rpm), since a fan effect caused by purely radially located ribs can accordingly not occur. The bracing ring 88 and the bracing ribs 90 are made increasingly thin radially from the inside outward, so that in injection molding, the material can flow rapidly from the inside outward with little resistance and fill all the voids in the injection mold.

An inventive quality is ascribed to all the individual characteristics listed above, since individually and jointly they contribute to the particular advantages of the embodiment described.